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Characterisation and Analysis of Municipal Solid Waste in Kuching

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Characterisation and Analysis of Municipal Solid Waste in Kuching

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DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Malaysia Sarawak. Except where due acknowledgements have been made, the work is that of the author alone. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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ABSTRACT

The composition of waste disposed of is crucial for planning and decision-making of a sustainable waste management system. The municipal solid waste (MSW) from three principal council areas in Kuching, which are Kuching South City Council (KSCC), Kuching North City Hall (KNCH), and Padawan Municipal Council (PMC) are collected and characterised. This waste composition is evaluated for the sample collected directly from the source and lab analysis is conducted on the sample collected from the landfill. The municipal solid waste samples are collected directly from the pre-categorised source location according to the socio-economic level. The municipal solid waste generated in Kuching city has been analysed by using both qualitative and quantitative analysis, as well as characterising the municipal solid waste samples based on their physical, chemical, and thermal characteristics. This study discovered that there is no significant difference in the waste composition trend generated in different residential areas. Organic waste is found to be the highest waste component in all socio-economic groups. For the residential areas, the top three waste compositions are organic wastes (61.58% w/w), plastics (12.06% w/w), and nappies/sanitary napkins (11.67% w/w). The sample collected from the landfill is divided into two groups, the sample from the new landfill where the solid waste was disposed of in recent two years and the old landfill where the solid waste was disposed of more than 5 years. The moisture content, volatile matter, ash, and fixed carbon content were 54.71%, 26.42%, 18.67% and 0.21% respectively for the old landfill and 63.26%, 22.83%, 13.73% and 0.18% for the new landfill sample. The calorific value for the old landfill sample is found 2041.86 kcal/kg and the calorific value for the new landfill sample is found 2891.9 kcal/kg. Thus, the thorough evaluation in this study reveals that landfill waste is not suitable for waste to energy incineration process. The amount of solid waste

generated in Kuching city is increasing in trend as the population in Kuching city is increased. A sustainable waste management system with a zero-waste approach is proposed in Kuching city.

Keywords: Kuching, municipal solid waste, waste characterisation, proximate analysis, thermal analysis

Pencirian dan Analisis Sisa Pepejal Perbandaran di Kuching

ABSTRAK

Sisa pepejal perbandaran dari tiga kawasan majlis utama di Kuching, iaitu Majlis Bandaraya Kuching Selatan (KSCC), Dewan Bandaraya Kuching Utara (KNCH), dan Majlis Perbandaran Padawan (PMC)dikumpul dan dicirikan. Sampel sisa pepejal dikumpulkan terus dari lokasi sumber dan analisis lab dijalankan kepada sampel dari tapak pelupusan sampah. Sisa pepejal perbandaran dikumpulkan dari tempat persampelan yang dikategorikan mengikut tahap sosio-ekonomi. Sisa pepejal perbandaran yang dijana di bandaraya Kuching telah dianalisis dengan menggunakan analisis kualitatif dan kuantitatif, serta pencirian sisa pepejal perbandaran berdasarkan ciri fizikal, kimia dan habanya. Kajian ini mendapati tiada perbezaan yang ketara dalam trend komposisi sisa yang dicipta oleh penduduk di kawasan kediaman yang berbeza. Sisa organik didapati merupakan komponen sisa yang tertinggi dalam semua kumpulan sosio-ekonomi. Tiga komposisi sisa pepejal yang tertinggi ialah sisa organik (61.58 % b/b), plastik (12.06 % b/b), dan lampin (11.67 % b/b). Sampel yang dikumpulkan dari tapak pelupusan sampah dibahagikan kepada dua kumpulan, sampel dari tempat pelupusan baru iaitu sisa pepejal yang dilupuskan dalam lingkungan dua tahun lalu dan tempat pelupusan lama iaitu sisa pepejal yang dilupuskan lebih dari 5 tahun. Kandungan kelembapan, bahan meruap, abu dan kandungan tetap karbon adalah 54.71%, 26.42%, 18.67% and 0.21% untuk sampel dari tapak pelupusan lama and 63.26%, 22.83%, 13.73% and 0.18% untuk sampel dari tapak pelupusan baru. Nilai kalori untuk sampel dari tapak pelupusan lama adalah 2041.86 kcal/kg dan nilai kalori untuk sampel dari tapak pelupusan baru adalah 2891.9 kcal/kg. Kajian ini mendapati sampah di tapak pelupusan adalah tidak sesuai untuk loji pembakaran sisa pepejal kepada tenaga. Jumlah sisa pepejal di bandar raya Kuching

semakin meningkat apabila jumlah penduduk di bandar raya Kuching meningkat. Sistem pengurusan sisa dengan pendekatan sifar sisa telah dicadangkan di bandar raya Kuching.

Kata kunci: *Kuching, sisa pepejal perbandaran, pencirian sisa, analisis proksimat, analisis haba*

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LIST OF ABBREVIATIONS

% w/w	% weight/weight
ASTM	American Standard Test Method
CMCO	Conditional Movement Control Order
DOSM	Department of Statistics Malaysia
ED-XRF	Energy Dispersive X-ray Fluorescence
EPA USA	American Environmental Protection Agency
GDP	Gross Domestic Product
HDPE	High-Density Polyethylene
HHW	Household Hazardous Waste
HHV	Higher Heating Value
KIWMP	Kuching Integrated Waste Management Park
KNCH	Kuching North City Hall
KPKT	Housing and Local Government Ministry
KSCC	Kuching South City Council
LCA	Life Cycle Assessment
LDPE	Low-Density Polyethylene
LHV	Lower Heating Value
MRF	Material Recovery Facility
MSW	Municipal Solid Waste
NREB	Natural Resources and Environment Board
PET	Polyethylene Terephthalate
PMC	Padawan Municipal Council
PP	Polypropylene

PPE	Personal Protective Equipment
PS	Polystyrene
PVC	Polyvinyl Chloride
RDF	Refuse-Derived Fuel
RMCO	Recovery Movement Control Order
RORO	Roll on, Roll off
SDG	Sustainable Development Goals
SWA	Solid Waste Analysis
SWCORP	Solid Waste Management and Public Cleansing Corporation
WEEE	Waste from Electrical and Electronic Equipment
WTE	Waste-to-Energy

CHAPTER 1

INTRODUCTION

1.1 Study Background

According to the World Bank Group (2022), 2.24 billion tonnes of solid waste is generated per day in the year 2020. In the year 2018, approximately 0.74 kg of solid waste per capita in a day is generated (Kaza et al., 2018) and it increased to 0.79kg of solid waste per capita in a day in the year 2020. The annual waste generation is expected to increase to 3.88 billion tonnes in the year 2050.

According to the Strategic Planning and International Division, Ministry of Housing and Local Government in their KPKT Statistic 2020 report, an estimated 14.4 million tonnes of solid waste is generated in Malaysia annually. The solid waste generation rate is calculated at 1.22kg/capita/day as the population in Malaysia is 32.4 million in the year 2020 (DOSM, 2022). The number is higher than the global waste generation estimated by the World Bank Group. As the population of Malaysia is increasing by 1.7% annually (DOSM, 2022), there will be more solid waste generated if there is no significant change in the behaviour of Malaysian toward solid waste management. In Kuching, a report by Tang (2020) revealed that 690,000 kg of municipal solid waste was generated in the city every day. This study evaluated and analysed the current waste trend and compare the differences between the selected waste streams which prioritise recovery, and recyclable opportunities and suggest new strategies for waste management forethought.

1.2 Problem Statement

Moving forward to achieve sustainable development in Malaysia, 6 states in Malaysia, which are Johor, Perlis, Kedah, Pahang, Melaka and Negeri Sembilan and the Federal Territories of Kuala Lumpur and Putrajaya have started implementing waste segregation at source in the year 2015 under Solid Waste and Public Cleansing Management Act 2007 (Act 672). According to the annual report 2020 by Solid Waste Management and Public Cleansing Corporation (SWCORP), the recycling rate in Malaysia is in an increasing trend since the year 2015, mainly due to the implementation of the waste segregation practice. Referring to Figure 1.1, the recycling rate of Malaysia attained 30.7% in the year 2020.

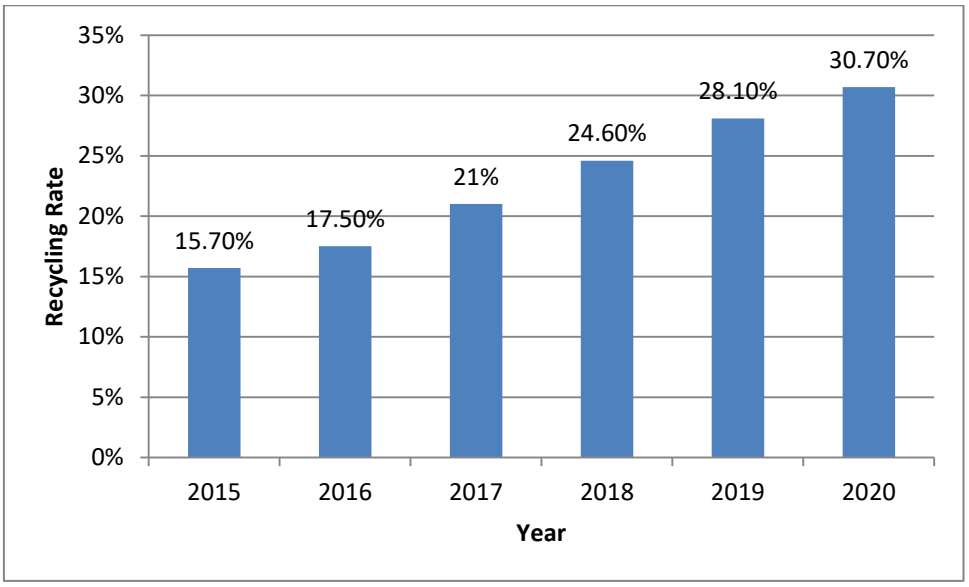

Figure 1.1: Recycling Rate Malaysia (SWCORP, 2022)

Although the recycling rate of Malaysia is increased, the recycling rate is still low when compared to Singapore, which has a recycling rate of 55% w/w in the year 2020. (National Environment Agency, 2022). The composition of plastic waste in municipal solid waste is remained high as well, recorded as 22.6% w/w (SWCORP, 2022).

Compared with Peninsular Malaysia, Sarawak is yet to change its regulation to enforce recycling activity. There is no recent municipal solid waste composition study at the Local Authority level as well (Tang, 2020). As there are differences in social and economic activities between Peninsular Malaysia and Sarawak, the waste composition in Peninsular Malaysia might be different from the waste composition in Sarawak or Kuching city.

Disposal of waste is the last option in the solid waste management hierarchy as it is not a sustainable solution for solid waste. Nowadays, even though the concept of waste-to-energy is prioritized over the recycling concept, the Housing and Local Government Ministry (KPKT) of Malaysia had planned to set up six waste-to-energy (WTE) plants by 2025 (The Malaysian Reserve, 2022). During the year the 1990s, four municipal solid waste incineration pilot plants are built at Langkawi, Tioman, Pangkor and Labuan. All of the pilot incineration plants were discontinued due to the high moisture content of the municipal solid waste, which lead to high fuel consumption in the incineration process. There is no expertise to operate the incineration plants as well (Shafie, 2019).

Although having similar weather conditions to Malaysia, Singapore has run their WTE incineration plant for solid waste disposal successfully. Compare with Malaysia, their solid waste is segregated before it is sent for disposal and the composition of food waste is only 21% (National Environment Agency, 2022) which indicates the lower moisture content of their solid waste. Hence, the key factor of a successful WTE plant is waste segregation to sort out the organic waste with high moisture content to increase the calorific value of the solid waste.

The landfill in Kuching which is located at Kuching Integrated Waste Management Park (KIWMP) has been operated since the year 2003. As it has been in operation for more than 20 years, the physical, chemical and thermal characteristics of the disposed solid waste might change over a long period via the bio-chemical degradation process.

1.3 Research Gap

The recent characteristic study of solid waste at source and solid waste disposed of in landfill is required for the implementation of sustainable and zero waste management in Sarawak. The facts about the composition of waste disposed of are crucial for planning and decision-making of a sustainable waste management system. Efficient methods are needed to assess the effect of legislative, logistic, and technical measures on the waste streams. The effect of such measures can be assessed by routine determination of solid waste composition and trends. (Brunner et al., 2004).

However, there is no recent details study on the solid waste composition in Kuching city. The most recent waste composition study specifically for Kuching city was conducted in the year 2003 by a consultant company, COWI. The current solid waste composition in Kuching city is unknown.

Yi (2019) reported that average 39.1% w/w of the solid waste in the studied landfills in Korea are combustible waste and the waste are recommended to be incinerated in waste to energy incineration plant for energy recovery. However, in Kuching, there is no study of the disposed waste at the landfill to determine the suitability of the disposed waste as a feedstock for waste to energy incinerator plants.

A study by Tufaner (2021) concluded that zero waste target is possible to achieve by combination of waste reduction, waste recycling, biogas harvesting from anaerobic digestion, and organic fertilizer production. However there is no similar study has been done for Kuching city. This research is conducted to study the solid waste composition in Kuching city and proposed zero waste management in Kuching by using the latest solid waste composition data from this study.

1.4 Hypothesis

This study is designed to access the hypothesis that:-

i) The composition of solid waste in Kuching city is similar to the national solid waste composition, with organic waste as the highest fraction of the waste, followed by plastic and paper.

ii) The amount of solid waste generated in Kuching city is increasing in trend as the population in Kuching city is increased.

iii) The solid waste disposed at the landfill can be considered as a feedstock for waste to energy incinerator plants.

iv) A sustainable waste management system with a zero-waste approach is feasible in Kuching city.

1.5 Research Objectives

The main focus of this project is to characterise and quantify the solid wastes generated in the city of Kuching in the state of Sarawak, Malaysia in establishing the trends of municipal solid waste generated and to propose a sustainable solid waste

management system with a zero waste proposition. The project, therefore, aims to accomplish four specific goals as stated below:

i) Quantifying solid wastes generated for a better understanding of the types and amounts of generated wastes using both qualitative and quantitative analysis;

ii) Analysing as well as characterising solid waste samples based on their physical, chemical, and thermal characteristics along with establishing the trends in the quantity of municipal solid wastes generated; and

iii) Proposing a sustainable solid waste management system with zero waste.

1.6 Scope of Study

The present study focused on the characterization of municipal solid waste generated in Kuching city. A sampling plan is established based on the social-economic level of the study area. The sampling period for the municipal solid waste from source is from October 2020 to November 2020. For the physical and chemical laboratory analysis, the sampling is done at a sanitary landfill in Kuching. The physical, chemical and thermal characteristic of the solid waste from landfill is analysed. A waste management plan is proposed based on the output from the solid waste characterization output and the physical, chemical and thermal characteristics of the municipal solid waste generated in Kuching city.

CHAPTER 2

LITERATURE REVIEW

2.1 Solid Waste

2.1.1 Definition and Criteria

Solid Waste and Public Cleansing Management Act 2007 [Act 672] is introduced by the Malaysia government in the year 2007. As defined in the act, solid waste includes:

(i) Any scrap material or other unwanted surplus substance or rejected products arising from the application of any process.

(ii) Any substance required to be disposed of as being broken, worn out, contaminated or otherwise spoiled.

(iii) Any other material that according to this Act or any other written law is required by the authority to be disposed of, but does not include scheduled wastes as prescribed under the Environmental Quality Act 1974 [Act 127], sewage as defined in the Water Services Industry Act 2006 [Act 655] or radioactive waste as defined in the Atomic Energy Licensing Act 1984 [Act 304];

Typically solid waste can be divided into two main groups, which are municipal solid waste and hazardous solid waste. Municipal solid waste is the solid waste collected from municipalities including household waste, commercial waste and construction waste meanwhile hazardous solid waste is the solid waste that has potential threats to public health or the environment which includes industrial waste, biomedical waste and special waste. Solid wastes were classified as hazardous waste if they exhibited one or more of the following characteristics, ignitability, corrosivity, reactivity or toxicity.